

EXPLANATION OF PLATE XIII.

- FIG. 1. *Millestroma Nicholsoni*, nov. Turonian: Abu Roasch, Egypt. Fig. 1*a*, half of the cœnosteum, showing the knobbed surface (*a*) and the sinuous grooves (*b*); nat. size. Fig. 1*b*, transverse section across the same specimen, showing the gastropod which forms the nucleus of the cœnosteum; nat. size. Fig. 1*c*, part of the surface of the same specimen; $\times 8$ diam. (*a*, cyclo-system; *b*, weathered part of the surface, showing reticular structure of the cœnosteum). Fig. 1*d*, part of a horizontal section across the same specimen; $\times 8$ diam. (*c*, horizontal canals). Fig. 1*e*, part of a vertical section across the same specimen; $\times 8$ diam. (*p*, pillars; *t*, tabulæ; *c*, calcite crystals).
- FIG. 2. *Sporadipora dichotoma* (Mos.). Part of a transverse section through the margin of a cœnosteum, cutting the marginal zooids vertically; $\times 8$ diam.
- FIG. 3. Ditto, part of another section from the same, showing the central zooids cut transversely, and the extensive vesicular tissue; $\times 8$ diam.
- FIG. 4. *Heliopora cœrulea* (Ell. & Sol.). Part of a transverse section across the central part of a corallum, showing a large gastropore; $\times 8$ diam.
- FIG. 5. *Hermatostroma episcopale*, Nich. Devonian: Devonshire. Part of a vertical section showing the pillars and tabulæ; $\times 8$ diam. (After Nicholson.)

II.—NOTES ON THE CORRELATION OF THE LOWER CARBONIFEROUS ROCKS OF ENGLAND AND SCOTLAND.

By WILLIAM GUNN, F.G.S., of H.M. Geological Survey of Scotland.

THE substance of the following paper was given at a meeting of the Geological Society of Edinburgh on January 20th this year. Its object is to show that the group of Lower Scottish Limestones about Dunbar and round the Midlothian Coalfield does not represent any part of the Mountain Limestone of Yorkshire, but is the equivalent of the upper part of the Yoredale Series of Phillips, while the Edge Coals and Upper Limestones of Midlothian represent a series of beds which in Yorkshire and Northumberland lie above the true Yoredale Series of Phillips, and which were included by him in the Millstone Grit. It necessarily follows from this correlation that the lower part of Phillips' Yoredale Series, together with the Scar or Mountain Limestone of Yorkshire, are represented in Scotland by the Calciferous Sandstone Series, which is mainly a fresh-water deposit.

This correlation of the Lower Carboniferous rocks of the North of England with those of Scotland was determined in the year 1881, after an examination of parts of the coast of Haddingtonshire and Berwickshire in company with two of my colleagues, Mr. H. H. Howell, now Director of the Geological Survey, and the late Mr. W. Topley, who both accepted at the time the general views here stated. Mr. Topley thought them of so much importance that he wished to join with me in writing an elaborate paper on this correlation, and I drew up some notes on the subject, but for various reasons the paper was never completed or published. However, the principal results have been from time to time orally communicated to several of my colleagues.

To illustrate the paper four vertical sections are given representing the rocks below the Millstone Grit, each section being drawn to the scale of 600 feet to an inch. The most southerly of these gives the succession of beds from the top of Ingleborough down to the

basement conglomerate which rests unconformably on the highly inclined Silurian rocks. The lower part of the section is composed of a solid mass of limestone, 600 to 700 feet in thickness, while the upper part consists mainly of an alternating series of sandstones, shales, and limestones, to which Phillips gave the name of Yoredale Rocks, because he considered they were typically developed in Yoredale (Wensleydale). In this and the other sections the limestones are particularly marked, because it is by means of them principally that the rocks in different places are correlated. The Yoredale Series, then, in the Ingleborough section ranges from the Hardraw Limestone up to the highest limestone—the Main or Twelve-Fathom—but two of the limestones generally occurring elsewhere are wanting in this section, so that it is certainly not a typical one of the Yoredales. Above the Main Limestone here there occurs a thickness of 100 to 120 feet of shale, and the hill is capped by coarse Millstone Grit.

The Wensleydale section is mainly that proved in Keld Heads Mine between Leyburn and Redmire. It will be noticed at once that the Yoredale Limestones are here both thicker and more numerous than at Ingleborough. Four of the limestones are each about 60 feet in thickness, whereas only the Main Limestone on Ingleborough attained this thickness. The two additional limestones are the Underset and the thin limestone next below. It should be stated that the Underset is here abnormally thin, it being usually about twice the thickness given. The 'Fossil' Lime, on the other hand, is usually only about one-half of the thickness here given, so it must be understood that the section does not stand for the whole of Wensleydale. The Main Limestone is often, perhaps generally, considerably more than 60 feet thick; in fact, it obtained the name of 'Twelve-Fathom' because it approximates to 72 feet in thickness. The upper part only of the Mountain Limestone is to be seen in Wensleydale, and its total thickness here is unknown, but it has already, as far as its upper members are concerned, begun to admit intercalations of sandstone and shale, and thus to approximate in character to the Yoredale Series above. In the dales to the north of Wensleydale somewhat similar sections may be obtained, and therefore it is unnecessary to give a detailed account of each. In the first valley, that of Swaledale, the section is very like that of Wensleydale, except that some of the limestones are thinner. In Teesdale we find that the Middle Limestone has separated into three limestones known as Scar, Cockleshell, and Singlepost Limestones, while nearly all the Yoredale Limestones, except the Main, are considerably thinner than in the dales farther south. Several comparatively thin limestones represent the upper part of the Great Scar Limestone of Ingleborough, while the lower part is a solid mass of about 200 feet in thickness, known locally as the Melmerby Scar Limestone. Below this is a variable but not thick mass of basement conglomerate, resting on the Silurian rocks which are exposed in the valley between the High Force and Caldron Snout. Not many miles to the west, in the Pennine escarpment, a thick series of sandstones occurs

below the Melmerby Scar Limestone, so it is evident that the floor on which the Carboniferous rocks were deposited was a very uneven one.

The section in Weardale is very similar to that in Teesdale, except that the Lower Carboniferous rocks are not reached.

When we reach Northumberland we find that the Mountain Limestone of Ingleborough is divided by intercalations of sandstone and shale so as to resemble in character the Yoredale Series above. This was long ago pointed out by Phillips, who says:—"The principal changes, as we proceed northward, appear to happen in the lower part of the limestone group, which loses its individuality, by admitting between its beds a constantly increasing quantity of mechanical admixtures, and at length becomes a subordinate feature in a country which has the characters of a coalfield."¹ As we proceed from South to Mid-Northumberland, while the upper or Yoredale Limestones are generally persistent, the lower limestones representing the Great Scar gradually become thinner and less important, and in many cases disappear entirely, so that eventually we find that nearly all the important limestones are in the upper or Yoredale Series. The work of my colleagues on the Geological Survey, as given in the published maps, is the authority for this part of Northumberland.

For Mid-Northumberland reference may be made to the admirable memoir by the late Mr. Hugh Miller on "The Geology of the Country around Otterburn and Elsdon" (1887), in which the announcement was made (see p. 5) of the identity of the Redesdale Limestone with the Dun Limestone of North Northumberland. Mr. Miller and myself had many conferences on the correlation of the Lower Carboniferous rocks, and he entirely concurred in the main results embodied in this paper. In this district the next limestone above the Redesdale is called the Fourlaws, and both these limestones traced into South Northumberland are found to lie far below the true Yoredale Limestones, and they therefore are portions of the Great Scar.

The North Northumberland section, somewhat generalized, is represented in the third column where the Dryburn Limestone is the uppermost of the Yoredales. Coals occur throughout the series down to the Fell Sandstones, but are omitted generally for the sake of clearness. It will be seen that the principal limestones fall into two natural groups, in the upper of which the limestones are numerous and pretty frequent (down to the Oxford), while several hundred feet lower come the Woodend and the Dun Limestones. Below these is the group containing the Scremerston Coals, 800 to 900 feet thick, in which also limestones occur, but they are always thin (from 1 to 4 feet each), and are for the most part plant-limestones of an estuarine or fresh-water character. Underlying the coals is a thick sandstone group—the Fell Sandstones—and at the bottom of the section is a portion of the Lower Carboniferous group called

¹ Manual of Geology, p. 165 (1855).

Tuedian Beds by the late Mr. Tate, of Alnwick, on account of their being characteristically developed along the Tweed. In 1856 Mr. Tate described these beds as consisting of grey, greenish, and lilac shales, sandstones, slaty sandstones sometimes calcareous, thin beds of argillaceous limestone and chert, and a few buff magnesian limestones. *Stigmaria ficoides*, *Lepidodendron*, coniferous trees, and other plants occur in some parts of the group, but there are no workable beds of coal. The fauna consists chiefly of fish-remains, *Modiolæ*, and *Entomostraca*. Generally fresh-water and lacustrine conditions are indicated.¹ The thickness of this series along the River Tweed from Carham to Berwick must be between 2,000 and 3,000 feet, and there is no doubt that it is the equivalent of the lower part of the Calciferous Sandstone of Scotland. Sedgwick seems to have been the first to point out the true position of these rocks in the Carboniferous formation in his address to the Geological Society in 1831; and in notes supplied by him for the third edition of De la Beche's Geological Manual he expresses the opinion that the Carboniferous Red Sandstone of the Tweed is superior to the Old Red Sandstone, and is about of the age of the Great Scar Limestone of Yorkshire and Cross Fell.² The natural inference from this would be that the limestones above the Scremerston Coals belong to the Yoredale Series, and it will be seen that this is so far true that *most* of the marine limestones belong to that series, viz. those from the Dryburn to the Oxford inclusive. This set of beds is thinner altogether here than in Wensleydale, but the difference is principally in the limestones, which in Wensleydale amount to about 300 feet, while in Northumberland they are not much more than half that thickness.

Among the sandstones and shales that come between the Oxford and the Woodend Limestones, occurs a marked band of oil shale which is very constant in North Northumberland. It contains remains of fishes, plants, and *Ostracoda*, and will be met with again in the Scottish section.

In the Northumberland section, No. 1 Limestone is the Dryburn Limestone of Lowick and the Ebb's Snook Limestone of Beadnell, and is called further south in Northumberland the Ten-Yard Limestone. It is the Main or Twelve-Fathom Limestone of Wensleydale and Swaledale, the Great Limestone of Teesdale and Weardale, and is the uppermost member of Phillips' Yoredale Series.

No. 2 Limestone is called at Lowick the Low Dean, and at Scremerston the Sandbanks Limestone, while generally in Mid-Northumberland it receives the name of the Eight-Yard Limestone. It is called in North-West Yorkshire the Underset Limestone, and in Teesdale and Weardale the Four-Fathom.

No. 3 Limestone is the Acre Limestone of Lowick, where it is also sometimes called the Dunstone (which name must not, however, be confounded with the Dun Limestone, the lowest of the marine

¹ Proc. Berwickshire Nat. Field Club, vol. iv, p. 151.

² De la Beche, Geological Manual, 1833, pp. 391, 392.

limestones). Further south it receives the name of the Six-Yard Stone, and in Weardale and Teesdale it is called the Three-Yard. It is the Little Limestone, 12 feet thick, in the Wensleydale section.

No. 4 Limestone is the Eelwell of Lowick and the Main Limestone of Beadnell and North Sunderland, and farther south in Northumberland it is called the Nine-Yard. In Weardale and Teesdale it is the Five-Yard, and in Swaledale it goes by the name of the Third Set of Lime. It is the 'Fossil' Lime of Wensleydale.

Now it is these four limestones, with the intermediate strata, that form the group of limestones at Cat Craig, near Dunbar, which is the lower division of the Carboniferous Limestone Series of Scotland, and therefore these marine limestones of Scotland represent only the upper part of the Yoredale Series of Phillips.

The limestones numbered one to four have been traced almost continuously for nearly 100 miles, and we are certain of their identity, but the limestones below these have not been so traced, and there is some uncertainty about their exact equivalents. It seems most probable, however, that the six comparatively thin limestones, from 5 to 10 feet each, between the Eelwell and the Oxford, represent the Scar, Cockleshell, Singlepost, and Tynebottom Limestones of Weardale and Teesdale, and that the Oxford is on the horizon of the Hardraw Scar, or lowest bed of Phillips' Yoredale Series of Limestones. This much is certain, that the Woodend and the Dun Limestones are far below this horizon, and represent portions of the Mountain Limestone or Great Scar Limestone of Ingleborough. The Woodend is called in the Alnwick district the Hobberlaw Limestone, and in the Otterburn and Redesdale districts the Fourlaws Limestone, while the Dun is identical with the Redesdale Limestone. In Scotland generally these marine limestones below the Eelwell are represented by the estuarine Calcareous Sandstone Series. We have, however, a narrow strip of Lower Carboniferous rocks some six miles in length north of the Tweed, along the coast between Berwick and Burnmouth, and here most of the beds below the Eelwell can be observed, though the section near Berwick is a good deal faulted. Between the pier and the Fisherman's Haven the Eelwell, repeated by faults and folds, occurs four times over, the Oxford then is faulted against it, and in the area bounded by faults at the Bay of the Burgess' Cove occurs a set of beds of Tuedian-like aspect on the Oil Shale horizon. Northwards from this is a pretty continuous section from the thick sandstone above the Woodend Limestone down to the genuine Tuedians, which, with a steep reversed dip, are faulted against the Silurian rocks at Burnmouth. The Woodend and the Dun Limestones are thinner here than they are generally in Northumberland. The Dun or Lamberton Limestone may be followed along the coast for nearly three miles, and below it are found some at least of the Scremerston Coals, which were formerly worked at Lamberton, but were found to be poor and thin in comparison with the same seams south of the Tweed.

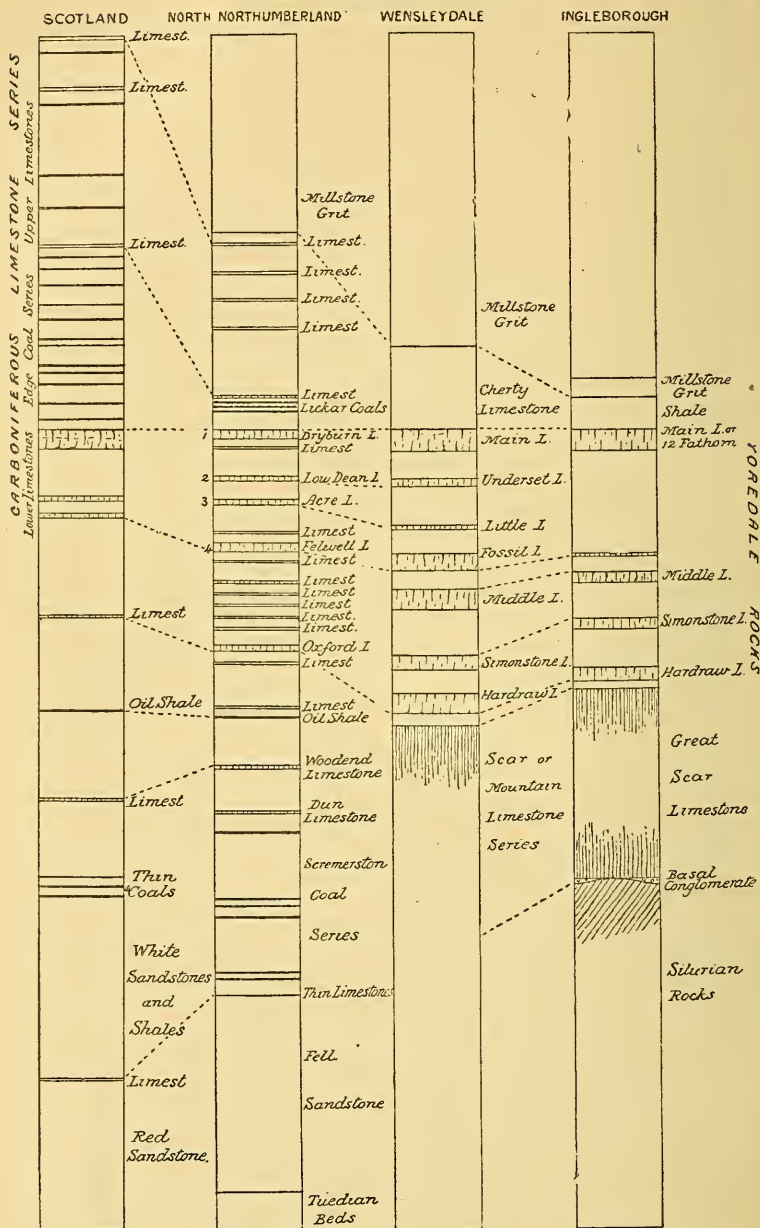
About 12 miles to the north-west, in a direct line from Burnmouth, Lower Carboniferous rocks are found on the coast of Berwickshire,

opposite Cockburnspath. We can recognize here in the white sandstones, interstratified with shales and with several thin and poor seams of coal, the representatives of the Scremerston Coal Series; the group of the Dun and Woodend Limestones is represented by a marine limestone in Cove Harbour, and in the next bay to the westward, immediately under the hamlet of Cove, occurs our well-marked band of oil shale. So far the section on this coast is very clear, but now the rocks which have been dipping steeply north or north-west flatten or undulate, though there seems to be a generally ascending series all along the coast to near Dunbar. Opposite Linkhead, 34 miles from Edinburgh, there is found an impure encrinital limestone, which seems most probably to represent the Oxford. Thus nearly all the lower limestones are dying out one after the other as we proceed westward, and at Skateraw most of the thin limestones between the Oxford and the Eelwell have disappeared, while at Cat Craig the lowest limestone is the Eelwell itself. My colleague Mr. Bennie, who has collected extensively both from the Acre Limestone of Lowick and from the second limestone (counting from below) at Cat Craig, has come independently to the conclusion that these limestones are the same, because they contain a similar assemblage of fossils. As all the rocks below the group of marine limestones at Dunbar have been classed as Calciferous Sandstones, it is now clear that the latter include representatives in time of the lower half of the Yoredale Rocks and the whole of the Mountain Limestone; and possibly the lowest part is older than the Scar Limestone of Ingleborough.

The upper part of the Scottish sectional column, viz. that called Carboniferous Limestone Series, is copied from that given by Mr. Howell on p. 73 of the Survey Memoir on the geology of the neighbourhood of Edinburgh, and it represents the Edge Coals of Midlothian Coalfield. Here we have a great development of coal-seams above the uppermost Yoredale Limestone, and higher up three thin marine limestones also accompanied by coal-seams. We have undoubtedly in Northumberland the equivalents of these upper limestones, also associated with workable coals, which, however, have been omitted from the Northumberland tables; lower down we have, close together, three or four coals which have been worked at Lickar, near Lowick; and elsewhere in Northumberland they are known as Little Limestone Coals. It seems pretty clear, then, that the Edge Coal Series of Midlothian is but an extraordinary development of these Lickar Coals. Even the total thickness of the beds in the Scottish section, some 1,300 feet from the lower limestones up to the Millstone Grit, can be matched in some parts of Northumberland. In Wensleydale this series is represented by a peculiar set of cherts, cherty limestones, etc., which cannot here be described, and on Ingleborough by a mass of shale. The term Yoredale was by the Geological Survey extended so as to include these beds, but they were classed by Phillips with the Millstone Grit, though sometimes he seems to have included a portion of them in his Yoredale Series.

It will thus appear how far from the truth was the old view that

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LOWER CARBONIFEROUS ROCKS.



Corrigendum: for 'Felwell' (in middle of plate) read 'Eelwell.'

the Carboniferous Limestone Series of Scotland represents both the Yoredale Rocks and the Mountain Limestone of England, and that the Calciferous Sandstone is older than the Mountain Limestone. The newer reading, that the Scottish Limestone Series is the equivalent of the Yoredale Beds, and the Calciferous Sandstone of the Mountain Limestone, is a nearer approximation to the truth, but is still far from being correct, especially as it has been shown that the greater part of the Scottish Carboniferous Limestone Series, including the upper limestones and the whole of the Edge Coal Series, lies above the position of the Yoredale Beds of Phillips.

III.—THE SOLENT RIVER.

By the late Sir JOSEPH PRESTWICH, M.A., D.C.L., F.R.S.

(Communicated by Lady Prestwich.)

[The idea of a great river flowing through the Solent before the Isle of Wight was separated from Dorsetshire, was very clearly stated in 1862 by the Rev. W. Fox, who for many years was Curate of Brixton, in the Isle of Wight (*Geologist*, vol. v, p. 452). The subject was further dealt with two years later by Sir John Evans (*Quart. Journ. Geol. Soc.*, vol. xx, p. 189), and subsequently by Mr. T. Codrington (*ibid.*, vol. xxvi, pp. 541, 544). Sir John Evans has since entered more fully into the subject ("Ancient Stone Implements, etc., of Great Britain," and *Nature*, vol. xxvi, p. 532); and it was briefly discussed by Sir J. Prestwich in his paper on "The Raised Beaches and 'Head' or Rubble-drift of the South of England: their Relation to the Valley Drifts and to the Glacial Period; and on a late Post-Glacial Submergence" (*Quart. Journ. Geol. Soc.*, vol. xlviii, p. 274).

The following article was marked by Sir J. Prestwich as "part of Submergence paper as first written but reserved for a separate paper."—H. B. W.]

AT Portsea Island a change takes place in the character of the drift, the 5 to 6 feet of gravelly clay forming the "Head" on the Old Beach to the east, being replaced on the same level by a bed of gravel, which, according to Mr. T. Codrington, attains a thickness of 27 feet, and still contains some boulders similar to those of Hayling Island, together with blocks of sarsenstone. To the west of Gosport the ground rises and the low cliffs of Stubbington and Hill Head are capped by 10 to 15 feet of gravel of a somewhat different character. No foreign boulders are to be seen in it, though I have found pebbles of quartzite derived apparently from the Triassic strata of Devonshire, as also some small subangular fragments of granite and other old rocks, large blocks of Tertiary Sandstone, and a few worn fragments of a fresh-water limestone¹ containing small *Lymnææ*. There are no shells either fluviatile or marine, and no beach underlies the gravel which rests directly on the Tertiary strata. It is intercalated with seams of sand and loam

¹ Derived from the opposite coast of the Isle of Wight.